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**KIT NEWS**  
News from the up and coming DIY hi-fi scene.  

**HIGH DEFINITION AEROGEL TRANSMISSION LINE MONITOR LOUDSPEAKER**  
A standmounting monitor loudspeaker using transmission line loading for deep and powerful bass and a 6.5inch HDA driver for super clear midrange.  

**KNOW YOUR PREAMP VALVES**  
We explain nine of the best known preamplifier valves around, suggesting where they should be used and what they sound like.  

**BOOK REVIEWS**  

**AUDIO FREQUENCY AMPLIFIER DESIGN**  
Audio Frequency Amplifier Design, originally published by the General Electric Co., has recently been revived by Old Colony Sound Labs. It contains many classic amplifier designs produced by GEC’s Research Lab Engineers.  

**THEORY AND DESIGN OF LOUDSPEAKER ENCLOSURES**  
J. E. Benson's Theory and Design of Loudspeaker Enclosures is a book for experienced designers wishing to take their understanding of this subject further.  

**DIY LETTERS**  
Our team of in-house experts can help you with your loudspeaker project, valve or solid state amplifier design and all other areas of DIY hi-fi. Write in with your letters and queries.
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NEW SERVICES FROM GT Audio
GT Audio have recently discovered a new range of capacitors which are particularly suitable for Quad II valve amplifiers. They are available separately or can be incorporated into GT Audio’s restoration service. Also new from GT is a 4mm socket and plug suitable for amplifiers, made from silver plated copper. 4mm sockets are available for £2 each and the matching plugs cost £2.50.

Because of the difficulty finding original Philips ECG 8417 output valves for Quicksilver monoblocks, GT Audio have developed a conversion which allows the reliable and more available 6550 output valve to be used instead. GT claim that this not only makes the amplifier more reliable, but also improves sound quality. The price for the modification, including valves, is £275.

GT Audio are also offering an upgrade service for Audio Research SP6/8/9/10 preamplifiers. Prices start at £100.

All labour carried out during restoration and parts purchased from GT Audio (except valves) are covered by a full 2 year warranty.

GT Audio
5 Upper Road, Higher Denham, Bucks, UB9 5EJ
Tel: 01895 833099

NEW SPEAKER KITS FROM FOCAL
Falcon Acoustics have just announced a new range of Focal loudspeaker kits.

There are eight to choose from, ranging from centre channel ‘speakers to a three way floorstander using a 10” bass unit. The range includes several designs using Focal’s polyglass and polykevlar drivers, and all are high sensitivity designs making them especially suitable for low power solid state and valve amplifiers.

Once you have built your own loudspeaker, Falcon can also supply the IMP loudspeaker measurement system reviewed in the February ’95 Supplement. For further details contact:

Falcon Acoustics
Tabor House, Norwich Road, Mulbarton, Norfolk. NR14 8JT
Tel: 01508 578272

MORE ISSUES FROM GLASS Audio
Glass Audio, the American magazine aimed at tube enthusiasts, is about to increase frequency from quarterly to every other month. For further information about Glass Audio and other Audio Amateur publications, contact:

Audio Amateur Publications
P. O. Box 576, 305 Union Street, Norwich Road, NH03458-0576 USA
Tel: (603) 924 9464

SINGLE-ENDED HEADPHONE AMPLIFIER FROM HART
New from Hart is a high quality single-ended headphone amplifier, the Chiara. Available as a kit, it comes complete with a printed circuit board which takes all components in order to make construction precise and easy. High quality audio grade components such as an Alps volume control are included. The Chiara has a signal link through to enable it to be connected between pre/power amplifier or to a tape monitor circuit.

The Chiara has two outputs suitable for headphones with an impedance greater than 30Ω. In addition there is a high level output, which can be used to drive long cable runs to a remote power amplifier for example, and a passive output. Both are controlled by the Alps volume control.

A complete kit of parts including casework is available for £109.50.

Hart Electronic Kits
Penylan Mill, Owestry, Shropshire. SY10 9AF
Tel: 01691 652894

WILMSLOW MAKE CABINETS AVAILABLE FOR KEF’S CONSTRUCTOR SERIES
Wilmslow have a number of new products that will be of interest to the DIY enthusiast. Firstly there is a range of flat pack cabinets under development for the recently launched KEF Constructor Series. Wilmslow can also supply drivers, crossover and any other components necessary to complete the kits.

Wilmslow Audio are also stocking the new D2905/9300 tweeter from Scanspeak. This new textile dome HF unit reaches 30kHz, giving it a very smooth response within the audio band. Sensitivity is a healthy 90dB and impedance a nominal 8Ω. The D2905/9300 retail at £59.50 each.

Wilmslow Audio
Wellington Close, Parkgate Trading Estate, Knutsford, Cheshire. WA16 8DX
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SOLID STATE REPLACEMENT FOR VALVE RECTIFIERS
RATA have introduced a solid state plug-in rectifier to replace GZ34 and GZ32 rectifier valves. The rectifier is mounted on an octal valve plug, so can be simply plugged in. In some cases it will be necessary to alter the HT dropper resistor to re-adjust for optimum working, RATA are able to advise on this.

RATA
Edge Bank House, Skelsmergh, Kendal, Westmorland. LA8 9AS
Tel: 0539 823247
Dominic Baker takes up his saw to build these High Definition Aerogel transmission line monitor loudspeakers.

To date, we've produced four loudspeaker designs in the pages of the DIY Supplement, the most recent two using Audax's Carbon Fibre drive units. Now it's time for Audax's High Definition Aerogel (HDA) drivers to make an appearance, in this compact standmounting transmission line monitor. Transmission line loudspeakers are known for their deep, powerful bass and the way they grip a room, filling it with a full scale performance. But they have their downsides too, notably the difficulty of tuning the line, which...
appears to be one of the blackest of arts.

Until recently we hadn't considered attempting such a design, but reviewing the book Quick & Easy Transmission Line Speaker Design by Larry Sharp, and a lengthy conversation with John Wright of TDL, a leading expert in transmission line loudspeaker design, prompted us to have a go.

The first cabinet worked very well, better than I'd hoped for at a first attempt. Bass was deep and powerful, but could become a bit monotonous. Shifting the internal baffles around gave me an idea of which way I needed to go to improve the bass quality, and the second prototypes were built. These were a great improvement, giving just about exactly the bass quality I wanted. It was still as deep, but the upper bass was faster and played tunes better, giving them a far more lively balance.

A couple more prototypes saw KLS5 quickly progress to its final form, thanks to our Hewlett-Packard HP3561A FFT analyser and an accurate measuring microphone.

One great thing about a transmission line loudspeaker is that once the cabinet dimensions have been optimised and fixed, it can be subtly tuned to give the bass quality you want in your room, just by altering the amount and density of long hair wool in the line. This makes Transmission Line loudspeakers extremely versatile for home constructors, which combined with their superb subjective performance, is why they're becoming increasingly popular once again.

TL DESIGN

A practical Transmission Line (TL) has two main effects that are advantageous to loudspeaker design. Firstly, the sound venting from the end of a quarter-wavelength transmission line is 90° out of phase with the signal from the back of the cone which drives the line, which itself is 180° out of phase with front radiation. This ensures that radiation at lower frequencies is progressively moving into phase and will add, rather than subtract, to the forward response.

Also, a practical transmission line loudspeaker is lined with acoustic felt and wool, so that the majority of upper bass and midrange energy is absorbed before it reaches the end of the line and the outside world. Lower bass energy gets through, making low bass apparent. In electrical engineering terms, a transmission line port is a low pass filter with a 270°+ phase shift.

The TWO25M0 tweeter used in KLS5 is very similar to the M1 version used in KLS3 and KLS4. It uses a 25mm soft fabric dome which gives it a sweet and open sound. It is more flexible for two way designs though, as it goes lower before rolling off.

The bass unit is a 6.5inch High Definition Aerogel (HDA) unit. HDA is made from a controlled matrix of acrylic polymer gel in which an optimised proportion of Carbon and Kevlar fibres are embedded. This makes it extremely light and stiff, as well as giving it high internal damping.

The drive units

The TW025M0 tweeter used in KLS5 is very similar to the M1 version used in KLS3 and KLS4. It uses a 25mm soft fabric dome which gives it a sweet and open sound. It is more flexible for two way designs though, as it goes lower before rolling off.

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Send for our list by fax details.
Because of the way the KLSS's transmission line has to be fitted into the compact cabinet, the tweeter is mounted below the main Aerogel bass/mid driver. In this situation, it's normally necessary to 'lobe' the loudspeaker's output towards the listener, otherwise a large proportion of the output from the tweeter would be firing at the floor or the ceiling. This is possible using third order filters, which although more complex, have other advantages. These include a faster roll-off rate which improves power handling as well as giving less 'overlap' between the two units, which can cause phase cancellations through the vertical axis.

The third order section for the treble arm of the crossover comprises a capacitor-inductor-capacitor circuit (C1-L1-C2), the values selected to provide a smooth response with the -3dB crossover point being 2kHz. Because the tweeter is slightly more sensitive, resistor R1 is used to attenuate it down to match the midrange output from the bass/mid driver. R2 is connected in parallel across the driver terminals to damp the impedance curve through the midrange, and provide a smooth and predominantly resistive load that makes them exceptionally easy for all amplifiers to drive, including low power, feedbackless, single-ended designs.

The crossover for the bass/mid unit again makes use of the parallel connected 22Ω resistor to damp impedance rise caused by the voice coil inductance.

A near field plot shows good integration between the HDA mid-range and fabric dome tweeter.

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All prices include V.A.T...
CONSTRUCTION

Building the KLS5s is fairly straightforward, as can be seen from the diagram below. I recommend you build them up on one side, leaving the back off to allow them to be lined with carpet felt and stuffed with long hair wool easily. The wood is thick enough to hold together strongly with just Evostick Resin Wood glue, but can be pinned or screwed together to hold the panels true.

The surface directly behind the bass unit and all of the surfaces in the top chamber should be lined with carpet felt to absorb reflections that would otherwise pass back through the driver. The transmission line needs to be filled quite heavily with long hair wool, around 250gm teased out and graduated so that it's most dense behind the driver and tapers out towards the end of the line.

The loudspeakers are handed for improved imaging qualities. When listening, the tweeters should be on the inside edges.
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High quality preamps should be wired with 16T.

And it's growing. signals of less than 100Hz a double run should be used.

"Note that the chassis wiring is excellent for loudspeakers internal wiring or to replace the jumper connectors used when Bi-wire speakers are used in single wire mode. When using the wire to carry signals of less than 100Hz a double run should be used. High quality preamps should be wired with 16T.

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SOUND QUALITY

by David Price

If you've ever experienced the Rolling Stones live and survived, you'll know what I mean when I say the KLS5s are exciting to listen to. Indeed, it was the aforementioned godfathers of rock that I auditioned them with. 'Start Me Up' is a song that spawned a thousand imitators (Primal Scream, you know who you are), and with the KLS5s you can see why - they jumped into the song with fantastic verve.

These loudspeakers sound highly involving. They certainly captured those classic Stones riffs with real power, projecting Mick'n'Keef's magic forcibly into the room. Charlie's rhythms were powered out in a raw yet couth fashion, wholeheartedly convincing me it was music I was listening to, pure and simple.

One of the most pleasing aspects of KLS5 was its cohesiveness. Black Uhuru's 'Emotional Slaughter' proved that in the face of complex, bass driven passages, these 'speakers remained utterly composed and together. They image very well to, forward and completely out of the box. Rhythmically, they remind me of Linn Kans - super fast, with an almost euphonic portrayal of rhythms - foot-tapping is compulsory.

The bass on the KLS5 is ultra fast, well controlled and highly rhythmic. Although surprisingly well extended for the 'speaker's fairly diminutive proportions, the bass isn't going to break windows. Moving the KLS5s away from the walls out into the room provided an extra degree of force in the lower regions. It's often the other way round, but transmission line designs drive rooms best when they've got some room to breathe. The KLS5's downside is their fussiness - as they don't suffer fools gladly, if the partnering equipment is duff or the recording poor, they won't equivocate - they'll tell you. This means you'll need a smooth sounding front end and amplifier. Don't even think about cheap CD players! If that doesn't dissuade you, you might just find they're an essential purchase.

Drive units available from World Audio Design - see page P. 85 in main issue.

MEASURED PERFORMANCE

The KLS5s have a smooth response, shown in the plot below. There is a slight peak in the midband around 1kHz, but it is narrow and only peaks by 1dB, so shouldn't be a problem in subjective tests. The treble has been gently rolled off at the top end to avoid brittleness or harshness with CD players and give it a sweeter balance.

Bass appears to roll off quite early, but the transmission line vents backwards so a lot of its output is lost with the microphone positioned close to the front of the 'speaker, where best midrange-treble detail can be resolved. All the same KLS5, because of its compact dimensions, doesn't have earth shattering bass. It rolls off gently, so although not strong, will go deep.

One of the great advantages of transmission line 'speakers is the highly damped impedance curve. Impedance varies little across the entire spectrum, giving them an especially flat impedance curve. This, along with their higher than average sensitivity of 88dB makes them an easy load, especially suitable for zero feedback valve amplifiers. Overall impedance measures 9.3Ω DB.
A selection of our stocks of New Original Mullard - Brimar audio types made in UK.

**STANDARD TYPES**

<table>
<thead>
<tr>
<th>Model No</th>
<th>Watts</th>
<th>P.I.M</th>
<th>Freq. Response</th>
<th>Application</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECC81 MULLARD</td>
<td>6.00</td>
<td></td>
<td>20Hz - 100kHz</td>
<td>12V 60V</td>
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<tr>
<td>ECC82 MULLARD</td>
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<td>ECL82 MULLARD</td>
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<td>EF86 MULLARD</td>
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<tr>
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<tr>
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<tr>
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<tr>
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**SPECIAL QUALITY TYPES**

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<th>Freq. Response</th>
<th>Application</th>
<th>Price</th>
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<td>E188CC - GOLD MULLARD</td>
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<td>ECC81 - M8162 / CV4024 MULLARD</td>
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<tr>
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<td>ECC83 - M8137 / CV4004 BRIMAR</td>
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**AMERICAN TYPES**

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**BLACKGATE CAPACITORS**

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<tbody>
<tr>
<td>2200uf</td>
<td>35V</td>
<td>PSU TOTAL DISTORTION - 150uB OR LESS</td>
<td>33.60</td>
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<tr>
<td>10000uf</td>
<td>63V</td>
<td>LESS COMPATIBLE WITH HIGH END</td>
<td>33.60</td>
</tr>
<tr>
<td>10000uf</td>
<td>63V</td>
<td>PERFORMANCE FILM CAPS</td>
<td>33.60</td>
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<tr>
<td>47uf X2</td>
<td>63V</td>
<td>VALVE PSU</td>
<td>33.60</td>
</tr>
<tr>
<td>10uf X2</td>
<td>63V</td>
<td>VALVE PSU</td>
<td>33.60</td>
</tr>
<tr>
<td>220uf</td>
<td>100V</td>
<td>GEC VERY LOW ESR, NON POLARISED USE IN Pairs</td>
<td>33.60</td>
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<tr>
<td>47uf</td>
<td>35V</td>
<td>GEC FOR VERY LOW NOISE</td>
<td>33.60</td>
</tr>
<tr>
<td>68uf</td>
<td>35V</td>
<td>GEC FOR POWER SUPPLIES</td>
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**TUBES (NOS. D. Boxes)**

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<tr>
<td>GZ34</td>
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<td>MULLARD</td>
<td>1000uf 40uf PHILIPS LOW ESR</td>
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<tr>
<td>EL34</td>
<td>30.00</td>
<td>MULLARD</td>
<td>4700uf 40uf RIPPLE CURRENT</td>
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<td>680F</td>
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<td>BRIMAR</td>
<td>MULLARD X-4 PANEL</td>
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**CABLE & SOLID TERMINALS**

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<th>Info</th>
<th>Price</th>
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<tr>
<td>19 STRANDED</td>
<td>AL-PLATED C/C</td>
<td>SILVER PLATED MC-CF (BLACK)</td>
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<td></td>
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<tr>
<td>19 STRANDED</td>
<td>AL-PLATED C/C</td>
<td>SILVER PLATED MC-CF</td>
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<td></td>
<td></td>
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<tr>
<td>KIMBER ASS Silver Cable Twists</td>
<td>99.99%</td>
<td>SILVER TELFON COATED - NOTHING BETTER</td>
<td>3.50</td>
<td></td>
<td></td>
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<tr>
<td>INSULATED SOLID TERMINALS</td>
<td>MULLARD</td>
<td>X-4 PANEL</td>
<td>3.50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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KNOW YOUR PREAMP VALVES

Selecting a valve for use in a preamplifier can be a daunting task, especially with so many to choose from. Andy Grove explains why and where to use nine of the most commonly available preamplifier tubes.

After a rather detailed explanation as to why I had selected a particular valve to use in a preamp, I was met with a blank expression and the reply - "the only way to design an amp is to plug in different valves and try it". You can do this with valves - being robust they won't blow up or burn out and, unlike transistors they will work under horrendously adverse conditions. But this isn't any meaningful way of assessing them. Valves must be run under correct DC conditions and within relevant small signal (AC) conditions before their sonic properties can be validly assessed. Here's a look at the role of various common preamp valves, together with operating conditions.

Before even buying any valves you need to scan the pages of your data books to find ones with the ELECTRICAL characteristics you are looking for. These comprise DC operating conditions and AC small signal parameters. My friend who listened by substitution wasn't considering either. A valve must be run within the manufacturer's specified DC conditions, notably anode volts, heater volts and, especially, grid bias, this last parameter intimately affecting AC performance.

The AC "small signal parameters" are valid only under the DC conditions, but they are not usually met in the real world, because quite often they involve running the valve at its absolute maximum ratings. Remember that manufacturers would try to make their valves look as impressive as possible in an attempt to outsell their competitors. So expect to "interpret" quoted AC performance; it won't turn out exactly as specified.

The small signal parameters for valves are gm - Transconductance (once called Mutual Conductance), μ (mu) - Amplification Factor, and ra - Anode Resistance. From these it is possible to get a good idea of how the valve will perform. Really μ, the amplification factor, is not strictly necessary because it is a product of gm and ra: μ = gm x ra. It is usually included because it makes life easier by simplifying some of the equations used to determine gain etc.

Now we have listed the parameters, what do they mean? They are really all about the anode current ia, in relation to the anode voltage Va and the grid bias voltage Vg.

1) Transconductance, gm, describes what happens to ia when Va is held constant and Vg is varied.

2) Anode resistance, ra, describes what happens to ia when Vg is held constant andVa is varied (note that ra is the valve's internal resistance, not the anode load, denoted Ra).

These parameters are used to find a valve's stage gain. The equation is: A = (μ x Ra)/(ra + Ra) where A is gain and Ra is the anode load impedance, ra and μ are as before. The anode load Ra could be a resistor, a transformer (inductive) or another valve (active load), as in a cascode stage.

The small signal parameters are AC parameters. They describe VARIATIONS in voltage and current and should not be confused with the valve's DC operating conditions. Also the words "Small Signal" are important; this phrase is the electronic engineer's way of describing the mathematical term "d" (lower case delta), a vanishingly small variation. Larger real world signals can alter parameters gm and ra, and also that they will continuously change over the AC cycle. This of course means that the gain of the valve alters with the signal. There is a term for this - nonlinearity.
KNOW YOUR PREAMP VALVES

ECC81/12AT7

The ECC81 is a double triode on a B9A base with 12.6V/6.3V series/parallel heater. It didn’t really catch on as an audio valve, and in the data books it is actually listed as a VHF type. Its highish mutual conductance of 5.5mAN together with its high amplification factor make it ideal as a cathode follower or cathode coupled phase splitter.

The ECC81 has a much higher gm than an ‘83 so gains in the region of 40 can be achieved with a single section, even though it’s \( p \) is only 55. The ‘81 will also work well as a cascode or at low voltages (\( V_a=75V \)) and its noise is low. The lowered anode impedance allows a better HF response than the ‘83 and better drive capability. Linearity isn’t really this valve’s forte though so I wouldn’t recommend it in very high level applications such as driving power triodes.

Sound quality is like a chrome plated version of the ECC83, with a bright, almost metallic upper midrange and much less of the ‘83s warmth. Some people like it, I don’t. Amplifiers with ECC81s include Tube Technology and Beard.

Equivalents:
12AT7 - USA, 6201 - USA mil version, 6060 SQ version, B309 - GEC. The ECC85 is very similar but has a different pinout.

Characteristics:
\( \mu = 55, \, gm = 5.5mAV/V, \, ra = 10k \)

at \( V_a = 250V, \, la = 10mA, \, V_g = -2V \)

ECC82/12AU7

The ECC82 is a double triode with series/parallel heaters and a B9A base. In fact the ECC81, ECC82 and ECC83 are all exactly the same valve, but with varying electrode spacing and grid pitch to achieve the different characteristics. The ECC82 is intended as a low impedance driver valve. Gains of around 12 are typical for a single stage, but more can usually be squeezed out if needed.

The ‘82 can deliver quite large currents at low anode voltages, making it useful as a cathode follower when a small amount of power is needed to drive the output stage. As a simple anode follower the ‘82 often finds itself as the last stage in preamps or as a driver for parallel-pair output stages. It is also sometimes used as a phase splitter/driver. If used in cathode coupled configuration, anode resistors must be adjusted to obtain balance.

Sound quality can vary depending on which type is used and of course how it is used. Generally it has quite a dull, unexciting sound, but this could be viewed as a lack of colouration. The ECC82, like the ECC83, is used by a lot of manufacturers, Audio Innovations and Border Patrol are good examples.

Equivalents:

Characteristics:
\( \mu = 17, \, gm = 2.2mAV/V, \, ra = 7.7k \)

at \( V_a = 250V, \, la = 10.5mA, \, V_g = -8.5V \)

ECC83/12AX7

This has to be the most widely used modern low level valve known to man. A double triode with 12.6V/6.3V series/parallel heater, B9A base and high amplification factor make it convenient to use in a wide variety of applications. Gains of 60 to 70 in one stage can quite easily be achieved. This allows one section of an ‘83 to replace a pentode in a lot of circuits, leaving the other section free for some other use.

The very high gain of this valve also makes it ideal for cathode coupled phase splitters, ensuring accurate balance. The Mullard 5-20 used one for exactly this reason. The valve is quite linear, but because of its high impedance it doesn’t accept high input/output signal levels. A good ECC83 has a warm, smooth sound, really valvey sounding - the Sovtek ones really excel.

Noise may be a problem in MC stages because of its rather low gm. I won’t bother listing who uses ECC83s because there isn’t enough room in the magazine!

Equivalents:
7025 - a selected version for audio, 12AX7 USA, B339 GEC, 6057 SQ version and 6L13 - Mazda. Type 5751 is similar but not identical, type 6EU7 is identical electrically, but has a different pinout.

Characteristics:
\( \mu = 100, \, gm = 1.6mA/V, \, ra = 62.5k \)

at \( V_a = 250V, \, la = 1.2mA, \, V_g = -2V \)
KNOW YOUR PREAMP VALVES

ECC88/6DJ8

The ECC88 is a double triode on a B9A base, with 6.3V only heaters and an internal screen. This is a special type of valve called a “Frame Grid Triode” so called because the grid is tightly stretched over a rectangular frame to allow very close spacing of the electrodes and hence the high gm.

Most ECC88s are INCREDIBLY microphonic! The very close spacing of anode-grid-cathode also means that the maximum voltage they can be used at is very limited or damage may occur. Standard ECC88s are almost exclusively used for preamps where they (if you know the right ones to use to avoid microphony) are very low noise, suitable for MC stages. The Sovtek 6922 however is useful as a driver valve as it has a higher voltage rating and anode dissipation.

Sound quality is very variable, some are horribly grainy, others mechanical, but some are crystal clear and smooth. The Telefunken E88CC is good, as is the Sovtek 6922 we use. ECC88s are very popular in the USA, especially with Audio Research and Conrad Johnson.

Equivalents:
6922 - mil spec, 6DJ8 - USA and 7308 - mil spec. The ECC89 is also very similar but with a slightly lower anode impedance.

Characteristics:
μ=33, gm=12.5mA/V, ra=2.65kΩ at Va=90V, la=1.5mA, Vg=-1.2V

12AY7/6072

This valve is similar to the ECC83 and has the same heaters/pinout. It was intended as a low noise preamp valve for audio use and as such it is excellent. Its characteristics are just about ideal for preamp applications, a gain of around 30 is typical for one stage and with a reasonably low output impedance.

Microphony on a good example is just about nonexistent, noise is low but an ECC88/6922 will win in the end due to its “brute force” gm. It would be sacrilege to use a 12AY7 as a driver valve, there are valves which are much better at being forceful. When used as intended though this particular valve has a rich, smooth and open sound which is very hard to beat.

The 6072 version is the high-reliability/ ruggedised military version and in my opinion it wins over its commercial cousin in the sound stakes, being slightly clearer and more coherent. The 12AY7 is slightly softer and more euphonic. The only people I know using the 6072/12AY7 are AudioNote and World Audio Design (in our 300B amplifier). The large voltage swing capability and low impedance make it a contender for driving triode output stages, although there are better, more linear valves.

As the 12BH7 can be used in such a variety of ways it is difficult to pin down its sound. In circuits I have tried it in though it sounds much like “an ECC82 with boots on”.

Equivalents:
I couldn’t find any equivalents but the 12BH7/A is very common so supply will not be difficult.

Characteristics:
μ=16.5, gm=3.1mA/V, ra=5.3kΩ at Va=250V, la=1.5mA, Vg=-10.5V

12BH7/A

The 12BH7 again has the series/parallel heaters and basing/pinout of the ECC81/2/3 type valves. Designed for use as a vertical deflection amplifier in TVs, its main application in audio is as a high powered driver valve. It looks like an ECC82 that’s taken an overdose of anabolic steroids and spent too long in the gym. The advantage with the 12BH7 is its anode dissipation of 3.5W and maximum anode voltage of over 300V. It can also deliver a lot of current (essential for deflection amplifiers) at Vg=0 making it a good choice for cathode followers.

To supply the very high voltage drive requirement of their distributed loading output stage McIntosh use 12BH7s with bootstrapped anode load resistors. Conrad Johnson and Audio Research also use them for similar reasons. The large voltage swing capability and low impedance make it a contender for driving triode output stages, although there are better, more linear valves.

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Characteristics:
μ=16.5, gm=3.1mA/V, ra=5.3kΩ at Va=250V, la=1.5mA, Vg=-10.5V
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6SN7
An Octal based double triode with 6.3V only heater; the 6SN7 ranks along with the ECC83 as one of the most popular valves of all time. A quick flick through the Radio Designer's Handbook shows its pages are littered with 6SN7s. It is one of the most linear valves of its class. A gain in the region of 15 for one stage is normal.

Generally noise and microphony are low, making this valve suitable in preamps as well as power amp driver stages and I would use it in place of an ECC82 in almost every application. The military used 6SN7s by the truckload and had special versions made. There is even an ultra high reliability version for missile and space applications - the 5692, famous for its bright red base, but don't try to buy any unless you've got a bulging wallet!

The sound quality of most 6SN7s is excellent, but like wine tends to get mellower with age. The later 6SN7VVGB or STC types have a lean, clean sound. The earlier ones are slightly softer, but all have a very open, natural quality. The best known application of 6SN7s in the UK is in the Williamson amplifier, which used GEC B65s.

Equivalents:
B65 - GEC, 5692 - Mil, B36 - GEC with 12.6V heater and 1251/17 - USA with 12.6V heater. The 6CG7 is a 6SN7 on a B9A base.

Characteristics:
$\mu=20$, $gm=2.6m\text{A/V}$, $ra=7.7k$ at $Va=250V$, $la=9mA$, $Vg=-8V$

6SL7
An Octal based high mu double triode with 6.3V heater. Like the 6SN7 this valve has been around for a long time and there are quite a few versions to choose from. The 6SL7 would be used in similar applications to the ECC83, phase splitters, low level preamp stages etc. Linearity is good but as with other high mu valves large voltage swings aren't possible. As a driver it will perform better than an '83 but not by much, its anode impedance is too high.

Although slightly less than that possible from an ECC83, a stage gain of around 50 is available from the 6SL7. Generally, microphony and excess noise are low but as its $gm$ is low at 1.6mA/V mc input stages aren't really practical. There are military versions which are ruggedised, ultra reliable and of course ultra expensive. The 5691 is the missile silo/Cape Kennedy version and is regarded as the best example. Used in a lot of older American equipment the 6SL7 has a warm but very clear sound. The later versions have a different presentation to the older types as with the 6SN7. Modern 6SL7 users include Cary and AudioNote.

Equivalents:
5691 - Mil, 6SU7 - matched sections for differential use and 12SL7 - 12.6V heater.

Characteristics:
$\mu=70$, $gm=1.6m\text{A/V}$, $ra=44k$ at $Va=250V$, $la=2.3mA$, $Vg=-2V$

EF86
The EF86 is a low noise pentode on a B9A base. It is intended for audio and designed with internal braking to eliminate microphony, and a helical heater/internal screen to prevent hum. The pins are arranged to minimise leakage from the anode and heater to the input grid.

Generally pentodes generate more noise than triodes because of the partitioning of current between the anode and screen grid. The EF86 has a special internal structure to minimise this problem, allowing high gain and low noise in a single valve. The gain available from a single EF86 will usually be in the 100 to 200 range, though going for the 200 mark may present linearity and frequency response problems.

The main use of this valve will be in the front ends of both preamps and power amps. There are some mega versions of the EF86, namely the Telefunken EF804S and GEC Z729/CV4085 both of which are expensive. The EF86 was used as the input stage of many Mullard and GEC circuits, our K588I also uses one.

Equivalents:
6267 - USA, 6F22 - Mazda, Z729 - GEC and EF83. There are two similar valves, the 6BS7 and 6BR7 based on the 6J7, an octal pentode. These however have different pinouts and one has a top-cap.

Characteristics:
$gm=1.85m\text{A/V}$, $ra=2.5M$ at $Va=250V$, $Vg=140V$, $la=3mA$, $Ig=0.55mA$, $VgI=2V$
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An Approach to Audio Frequency Amplifier Design.


It was an anonymous looking little book, with no dust cover and apparently no title, like so many in the box on the floor. Ferreting around has its compensations though. Along the spine, old gold lettering that had dulled through the years read: An Approach to Audio Frequency Amplifier Design - GEC. Inside lay a cornucopia of valve amplifier circuits, ranging from 5 watts to 1100 watts, no less. The last is a monster, designed for P.A. and distribution work (Rediffusion used them) running with a 2.5kV H.T. line feeding enormous VISOS output triodes. And no, we will not be making this into a kit!

You can, however, now drool over the circuit, should you be of such an inclination, because the book is being reprinted by the Audio Amateur Press, of New Hampshire, U.S.A., the same people responsible for Glass Audio, Speaker Builder and other specialist audio publications. It comes as a softback that retails at £19.95. If you want one you don't have to rise at the crack of dawn on Sunday to get to a swap-meet before the vultures swoop, since we are making it available through our library - an easier and more decorous way of getting books than grubbing around under trestle tables, I can assure you.

This reprint is a one-for-one copy of the original with no alterations or omissions. It contains a wealth of design data and general advice, all of which is invaluable for the modern day experimenter. GEC, like Mullard, kept their feet on the ground, majoring on practicalities and real life circuits, rather than theory. The book describes no fewer than seventeen different circuits, all designed, built and tested by GEC back in the early fifties. Most are power amplifiers, all are push-pull (no single-endeds), and preamps with phono equalisation and tone controls are also covered.

Parts lists, build details and even transformer winding data are given in order to make all the circuits potentially buildable from the book. However, there are some points to bear in mind. I've encountered two commercial amplifiers based on these circuits and neither worked properly. One was the 50 watt design that uses KT88s (p55) and in this case the feedback compensation scheme just didn't work. I stripped out the lot, re-compensated and got the design to work well (I can't supply details since this occurred many years ago). I suspect this might have been down to transformer differences.

Whatever, do bear in mind that transformer availability and the possible need to experiment with feedback to ensure stability may crop up. GEC discuss this in Appendix B entitled "Output Transformers and Stabilisation". An oscilloscope and square wave generator are helpful in this task.

Also, above 100 watts output, obtained from still-available KT88s using fixed bias, GEC use their DA42/100 power triodes, which aren't available any more. So whilst the six circuit descriptions make great reading, discussing Xenon rectifiers, U19s and operating voltages more commonly associated with the National Grid, building some of these designs is just about impossible.

Like the Mullard book on audio amplifiers, this one from GEC is required reading for anyone with a serious practical interest in valve amplifiers. I'm glad Audio Amateur Press have made it available again.

An Approach to Audio Frequency Amplifier Design is available through the Hi-Fi World Library.
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Theory and Design of Loudspeaker Enclosures

by Dr J. E. Benson.

Dr Benson is well regarded among top loudspeaker designers. He was the examiner for Richard Small's (of Thiele and Small fame) PhD thesis. Don Keele, another world renowned expert in the field of loudspeaker design wrote of this book "it is a classic, and even more comprehensive and detailed than Thiele and Small's loudspeaker papers as published in the Audio Engineering Society journal".

As you may have guessed from this introduction, the Theory and Design of Loudspeaker Enclosures is a serious affair, aimed at professional engineers. Much of the basis of the books is about creating a mathematical model of a loudspeaker enclosure, so the maths is quite complex, of degree standard or higher.

In the first chapter Dr Benson proposes a generalised configuration that encompasses all of the essential features of the various enclosure types, mechanical, acoustical and electrical. By varying the parameters of this generalised enclosure model, each of the individual enclosures (e.g. reflex, infinite baffle, sealed box, etc.) can be described by a mathematical expression.

The second paper then builds on these enclosure models by deriving the basic equations for calculation of the low frequency performance of a driver mounted into each of the different enclosure types. The 'performance' is described by the displacement, velocity and acceleration, sound pressure level and impedance, as well as response graphs. At this point it becomes clear that what Dr Benson is deriving is a set of equations that can be used in conjunction with a particular drive unit's parameters to describe its performance in a box, in exactly the same way as many of the 'low frequency box design' computer packages do.

These first two chapters set the basic equations for modelling a drive unit in an enclosure. The final chapter completes the exercise by introducing other box alignments not covered by the basic types, and introducing the effects of enclosure damping.

It is an extremely thorough book, and even though a lot of my degree maths is quite rusty, I was able to get a good feel for the way the enclosure models were developed and combined with a drive unit's parameters to predict the final performance as a whole. However, unless you're a mathematician with access to a computer who wants to design your own loudspeaker, or want to develop your own program for designing low frequency enclosures, it is a lot simpler to use one of the many computer packages already available. If you do want to know what the maths behind enclosure design looks like and how to use it, the Theory and Design of Loudspeaker Enclosures is one of the few that describes exactly how it's done.

The Theory and Design of Loudspeaker Enclosures is available from the Hi-Fi World Library.
### Golden Dragon

**RETAIL PRICE LIST**

Golden Dragon Pre-Amplifier Tubes

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Special Quality Golden Dragon Pre-Amplifier Tubes

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### Ceramic Sockets and Hardware

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  - 4.300B £84.00 £170.00 £340.00
  - 300B Super £79.00 £160.00 £320.00

### Golden Dragon Triodes

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  - 6DJ8/E88CC/ECC88
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  - 6L6WGB/881
  - 6L6GC
  - 6L6GA
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Letters

AFFORDABLE PHONO-HEADS
I enjoyed your recent article on phono-head amplifiers, but was surprised to see that you did not include any kits in the test.

For most of us, four or five hundred quid is a lot to pay for part of an amplifier. I built the Hart phono-stage which is powered by two PP3s (9 volt batteries). It’s easy to build (it was my first effort at assembling a printed circuit board) and it only costs £75. After the shock of finding that it worked first time, I then discovered it was a dramatic improvement over the phono-stage of my Musical Fidelity A100.

My LP playing system is now a Rock, Moth, Arcam P77Mg, the Hart and then a Beard BB100 into Ruark Talsmans. The sound is stunning and I’m sure that any of the phono-amps you tested would have a hard job to improve it.

Why doesn’t someone (you?) design an inexpensive battery-powered DAC for those of us just starting DIY hi-fi? Also, please include at least one low-cost kit in your comparative tests. I’m sure Hi-Fi World isn’t afraid of embarrassing big name manufacturers! Also as you are always complaining - and rightly so - about the lack of efficient loudspeakers, why devote three pages of your supplement to building some that are only 83dB.

David Kelly
St. Ives, Cambridgeshire.

The Hart kit was designed by John Linsley Hood and offers fine sound quality. At the price it is exceptional value. Our only small reservation is that for moving coil cartridges, there’s a little more hiss than is possible from today’s low noise solid state devices. With moving magnets, like your Arcam P77Mg, it will be as quiet as the best, however.

Digital convertors are complex and layout sensitive. They’re difficult to offer as a kit unless carefully designed and tested beforehand. Even manufacturers use the chip producer’s recommended board layouts, because this technology is so difficult yet critical. Those that don’t commonly run into obscure problems concerning RF pickup of high frequency digital in areas where it wreaks havoc.

Some readers have complained that the Audio Synthesis DSM and Audio Technology Sorcerer kit convertors we have tested to date are too expensive. Unfortunately, it isn’t necessarily cheaper to make a kit with some products. Volume industrial production has become so automated and fast that the usual savings on assembly and testing time are not there, machinery costs being spread over large production runs and many years.

The expense these days comes in design and development. Kits have to bear this cost, plus the additional expense of comprehensive build instructions. They are low volume items too, which raises casework costs in particular. Consequently, kits aren’t necessarily cheap to develop or manufacture. Savings often come in their direct-to-the-customer marketing or, in some cases, low development cost through use of industry-standard circuit arrangements.

The only other way of making a low cost kit is to eliminate all casework, offering only a board and bits.

We are interested in low cost kits and will review them whenever possible; the Maplin Millenium valve amplifier was a good case in point. But there aren’t so many real cheapies, for the reasons described. NK.

ECC807S SPOTTED
Tsk, tsk. It really won’t do! Fancy both Haden Boardman and Andy Gold saying ECC807S aren’t available anywhere. According to suppliers’ lists (and assuming some swine hasn’t bought up the world supply in the meantime), they can be had from Philip Taylor and Valve & Tube Supplies.

The address is: Philip Taylor, 3 Silver Lane, Billingshurst, Sussex. RH14 ORP (good for obscure types) and Valve & Tube Supplies, Unit 2A, Rink Road Industrial Estate, Ryde, Isle of Wight PO33 2LT Tel: 01983-811386 (large range).

Also, consult the Sound and Vision Yearbook for a fuller list of component suppliers, which is published annually at £3.50.

Andrew Emmerson
Northampton.

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Andrew Emmerson
Northampton.
Thanks for the reminder, but, I want to know, who’s Andy Gold? Is this a hybrid reviewer, part Valve, part Transistor?

Andy Grove, our valve expert, says they’re not in production and are rare. Consequently, we are not prepared to encourage people to buy amplifiers that rely on their use, for fear of suffering a more valid complaint, that we’ve encouraged someone to waste their money.

All the same, I’m sure readers will be glad to know that these valves may be available in small quantities and that a unique directory of valve suppliers is printed in The Sound & Vision Yearbook, available from the Sunrise Press, 2-4 Brook Street, Hampton, Tiverton, Devon EX16 9LY. NK

POSITIVE FEEDBACK

Thank you for your review of our valve amplifier kit as published in your constructor supplement, and we are pleased that you found the product very favourable. I am just writing to say that I have taken note of your comments in the ‘measured performance’ box, and to notify you of other small modifications that the design is currently undergoing.

Due to interest in the U.S. the PSU kit will soon be supplied with a dual 115/230V primary and other components, enabling it to be built and used by both European and U.S. customers.

The instructions with the kits are updated accordingly.

The amplifier kit will have revised earthing arrangements designed to improve the stereo image from a stereo assembly, and I have instigated PCB changes to relocate CB as per the Mullard circuit, as you have suggested in the review (we have also experienced minor oscillation problems on one occasion). However, it is not too difficult to terminate the low side of C8 to the PCB pin of V1 pin 3, instead of its normal PCB, on the original version of PCB by way of modification.

While I had tried to retain some semblance of originality in the Maplin version, so that the design is not obviously a direct copy of the Mullard 520,

VALVE SYNERGY

Thank you for your high standard magazine, especially the Supplement. I am a hi-fi enthusiast for more than 20 years (I’m 39) and I am very tired of seeing the industry moving towards mini-monitors, video and the like. My system is based around a Marantz 7c tube pre-amp, a Marantz 8b amp and a pair of ‘small’ IMF TLS-50s bought, used, 10 years ago. Many components came and went along the years, such as a Radford ZD-22 and ZD-100 power, but the IMF/Marantz combination proved to be a synergy love affair, as weird as it may look, I know. But the result must be heard to be believed. It seems that the Marantz with its 55 pounds of transformers has no trouble driving almost anything at reasonable levels while singing; better in fact than my previous 2 x 90 watt Radford which was much more dynamic but totally sterile.

By the way, thank you for your article about “Restore or renovate”. Now I know that I will never try to improve the already good work of Saul Marantz.

1) My amp. is 35 years old and seeming in perfect condition, but is there a way to check the values of capacitors, etc. to see if they have kept their values: or must I wait for the day something starts to smell toasted in the room? (who said that valves are not reliable?)

2) I found a pair of 15” Tannoy concentric (silver & 16Q) in a flea market for about £50. They were in bad home-made enclosures. Though what struck me was their dynamics (wow!) and the fine imaging, coherence and speed. What was wrong was a boomly bass and no low extension, probably due to bad resonant enclosure and ‘cup distortion’ in the midband that I can’t explain. A well-known expert tells me it is usually the amps, can it be so?

3) By the way, Lockwood Audio told me that the GRFs were built around these drivers, but I can’t find any plans to build these enclosures. Could you tell me where I could find these plans?

4) The Marantz amp can be run in triode mode, giving them nearly 20 watts instead of its 35 watts, ultra-linear. Would it help in getting a better sound from the Tannoy, or is it a ‘fake’ triode just for the fun of being a triode?

5) You see me coming! In the near future I plan to build a single-ended amp based on a 300B to drive the Tannoy or some horn speakers. Have you any plans to suggest? What do you think of Audio Note’s Kit One! and could your 4 watts SE amp drive the Tannoy and eventually a Lowther PM6 horn?

6) Last question: have you heard the PM6-based horn? What are their strong and weak points and do you plan to review them some day? Please publish my phone and fax number. Sylvain Giguère, Portnuef-Station, Quebec, Canada.

Fax:418 873 3868 Tel: 418 286 4736

Maplin’s Millenium 4-20 reviewed in the November ’94 DIY Supplement.

Letter of
it is again an example of Mullard getting it pretty well right in the first place, so that it has been extremely difficult to make Millennium different. I have to admit though that the subtleties of the EF86 screen grid uncoupling arrangement eluded me at the initial design stage. Ho hum!

Mike Holmes
Maplin Electronics, Essex.

INFECTED!
Help! Ever since I purchased my Rega Planar 3, which was auditioned through an Audio Innovations valve amp, I have had the valve bug. My current set-up is a Rega Planar 3/RB300/R100 turntable, Set-up, Denon PMA-300 amplifier, Denon DCD1290 CD player, Denon TU260L tuner and Tannoy Berkeley 'speakers.

I am a qualified electronics engineer with some time on my hands and as much as I would love an EAR 834 or similar esoterica, I would get more satisfaction from building my own amplifier as well as saving on costs.

I have circuits for the Mullard 5-20 power-amp and pre-amps, and the Williamson amplifier, but I have no idea what these amplifiers sound like.

I read with interest your article last month on the Maplin 4-20 amplifier kit although I was perturbed by the shortcomings on the transformer front, which is where savings have obviously been made, and also the physical appearance which reminded me of projects I once made at college 25 years ago! I would rather spend some more money on higher-rated transformers and have a reliable amplifier as a result.

Are there any other manufacturers out there who make a classic valve pre-amp and power amplifiers in kit form, and if so, do you have any experience of their sound quality, or indeed that of the original designs?

I have obtained a list of transformers and chokes from E.A. Sowter Ltd. in Ipswich, but it looks like a dismantled WW1 radio transmitter so if you have any form of partner, cat, dog, children, parents or for that matter anyone with working eyes in your house prepare for trouble.

Our 4W S.E. design will drive the Tannoy's loud because they are very sensitive at around 96dB/1W and the Lowthers even more so. The 4W amp has a beautifully warm and sweet sound which I'm sure you will love, and it looks as good as it sounds.

I have only heard vintage Lowther 'speakers but we will be listening to some new types soon. AG

On the question of power supplies, is it necessary to have a separate supply for each amplifier, or would a single supply give satisfactory results? Also what are the merits of using a solid-state rectifier as Maplin have done in their kit (apart from cost)? Would the large series choke in the supply line still be necessary, or is this all too much of a departure from the original Mullard design?

My apologies for a long-winded letter, but I am sure that there is a path to thermionic heaven out there somewhere.

PS: I abandoned my Garrard 401/SM 3009 52 due to excessive rumble and I have been very pleased with the replacement Rega. Are 401

The Month

components will need to be tested to ensure that, for example, none of the resistors have drifted out of tolerance and that none of the capacitors are leaking DC current. It may be better to take the amplifier to a good engineer as it is quite a classic and it would be a shame to watch it go up in smoke.

The “cup” type of distortion you are hearing is usually caused by severe frequency response irregularities, so I would immediately suspect the new 'speakers. The cones may be damaged or the voice coils sticking and as these were in home-made cabinets the cross-over may be suspect as well. Make sure you have the ‘speakers connected to the right output transformer tap. Connecting a 16Ω speaker to the 8Ω tap usually results in a very thin and weak sound.

Many of the top Tannoy 'speakers used the Dual-Concentric driver in one form or another, so you have quite a lot to choose from. Also, there are other enclosures which would suit the Tannoy drivers very well. How about a scoop horn enclosure or an enclosure based on the legendary Japanese Onken speakers? There are plans for the latter in Sound Practices No 4. Tannoy may be able to help on the GWF enclosures and probably the crossover as well.

My advice about triode connecting is to try it and see. You will probably find that it sounds more dynamic and musical. Triode-connected pentodes normally work well if precautions are taken against parasitic oscillation and I'm sure this is the case with the Marantz.

Keep your eyes peeled for forthcoming circuits and projects in HFW Supplements. S.E. triodes are our speciality and we have 211 and 300B designs coming soon. The Audio Note Kit One sounds great but looks like a dismantled WW1 radio transmitter so if you have any form of partner, cat, dog, children, parents or for that matter anyone with working eyes in your house prepare for trouble.

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WIN A MAPLIN SOLDERING IRON KIT COMPLETE WITH A LENGTH OF SILVER SOLDER

The writer of the most interesting DIY letter each month will receive a superb Maplin soldering iron, stand, booklet on good soldering practice and a length of high quality silver solder.

Write in to: Hi-Fi World DIY letters, 64 Castellain Rd, Maida Vale, London W9 IEX.
I have used Sower transformers in the past and they were fine, but you will really have to suck it and see if you are going to develop a project of your own. The phase shifts caused by the output transformer are an unknown quantity so you can't really just drop it into a circuit. Some experimentation is necessary with the feedback network. This is one of the advantages of buying a full kit - the circuit has already been optimized.

It is not absolutely necessary to use separate power supplies for each channel but it can help. Solid-state rectifiers are much more efficient than valve rectifiers and help reduce the cost of an amp, but for sonic purity and output valve longevity I can recommend valve rectification.

The 401 can be tweaked up to a very high standard. There are several companies offering this service, for example Loricraft, Slate Audio and Technical and General Supplies. AG

It's very nice to see the original Mullard Circuits For Audio Amplifiers now being reprinted. I still have my original version from the Sixties, which was a source of wonder and much fun at the time. However, more recently I have had to sort out a modern Mullard 5-20 that didn't work properly because of incorrect feedback compensation components, and I have met similar but larger problems with GEC's 50W design.

As Andy says, you have to set these feedback component values depending upon phase shifts around the amplifier, those in the output transformer being particular to the transformer used. Modern transformers often differ significantly to those used by Mullard and the feedback component values have to be adjusted accordingly, those given by Mullard and GEC commonly being unsuitable.

The experimenter can get a long way by applying feedback progressively, starting off with a high-ish value series "dropper" resistor in the feedback loop (say 8k) and dropping slowly until the amp breaks into oscillation, probably around 3-4k. Then increase the value by around 20% to give the unit a reasonable stability margin.

This is a bit ad hoc, but providing you err on the side of caution, meaning a high resistor value (6-8k) and least feedback, then the amp will be plenty stable enough into all loads. Do not try to use maximum feedback; it will not improve sound quality and the amp may well burst into occasional oscillation, which could destroy tweeters. Valve amps like this sound fine with low-ish feedback and in this state they are most stable.

Having set feedback level, the capacitor across R13 (C9) and that in series with resistor R3 (C1), should be adjusted for best square wave response. Use a 1kHz square wave driving 3V into an 8Ω resistor (3-11W). Viewing on an oscilloscope, make sure there's no significant leading edge droop as in a), indicating treble fall and a warm or dull sound, or leading edge peaking as in b), indicating treble lift and a bright or sharp sound. Try to minimise ringing too, as in c), which is indicative of a sharp supersonic treble peak attributable to leakage inductance and winding capacitance forming a resonant circuit. This may increase your stability margin and feedback can be increased a little after if desired. NK

Feedback components have to be set depending on phase shift around the circuit. A scope can be used to view square wave performance which gives a useful guide.

---

**Diagram**

```
R1 220k
R2 3.3k
R4 2.2k
R5 6.6k
R6 11k
R7 39k
R8 10k
R9 93
C1 47p
C2 0.05μ
C3 50μ
C4 310μ
C6 0.1μ
C7 560pF
C9 310pF
C16 0.1μ
C17 560pF
```

- **a)** Treble fall
- **b)** Treble lift
- **c)** Ringing

---

**Feedback**

Having set feedback level, the capacitor across R13 (C9) and that in series with resistor R3 (C1), should be adjusted for best square wave response. Use a 1kHz square wave driving 3V into an 8Ω resistor (3-11W). Viewing on an oscilloscope, make sure there's no significant leading edge droop as in a), indicating treble fall and a warm or dull sound, or leading edge peaking as in b), indicating treble lift and a bright or sharp sound. Try to minimise ringing too, as in c), which is indicative of a sharp supersonic treble peak attributable to leakage inductance and winding capacitance forming a resonant circuit. This may increase your stability margin and feedback can be increased a little after if desired. NK
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**MATCHING CHARGES**

- POST & PACKING (UK) £3.00
- TOTAL EXC VAT
- VAT @ 17.5% (UK/EEC ONLY)
- TOTAL TO PAY

Please make cheques payable to: ‘CHELMER VALVE COMPANY’ or pay by ACCESS/MASTERCARD/VISA Please give details:

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<th>SIGNATURE:</th>
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**VALVE AMPLIFIERS SOUND BETTER STILL WITH CVC PREMIUM VALVES!**

130 New London Road, Chelmsford, Essex. CM2 0RG. Tel: 01245 355296/265865 Fax: 01245 490064